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Marine Conditions and Automated Forecasts for the Atlantic Coastal Storm of February 18–20, 1972

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ABSTRACT—The storm surge and ocean waves associated with the Atlantic coastal storm of Feb. 18–20, 1972, caused extensive damage along beaches of Long Island and New England. Meteorological conditions of the storm, along with resulting tides, surges, and waves, are described. Comparison is made with forecasts of the storm produced by the primitive-equation model of the National Meteorological Center, as well as with automated forecasts of storm surge and wave height. It is concluded that the meteorological forecasts and the resulting storm surge and wave forecasts were quite good.

1. INTRODUCTION

The coastal storm of Feb. 18–20, 1972, caused extremely high tides with extensive damage and beach erosion along the northern portion of the U.S. Atlantic coast. Figure 1 shows structural damage to a house and pilings at Westhampton Beach, on the south shore of Long Island. Extensive damage to a parking lot at Jones Beach, N.Y., due to undermining, is shown in figure 2.

One purpose of this report is to document the meteorological aspects of the storm that affected the tide level and ocean wave conditions and to summarize the records of tide level, storm surge, and ocean waves. Another purpose is to examine the primitive-equation (PE) model meteorological forecasts of the National Meteorological Center (NMC) (Shuman and Hovermale 1968) and the resulting automated forecasts of storm surges and ocean waves.

2. METEOROLOGICAL DETAILS OF THE STORM

A low-pressure system centered over the Great Lakes at 0700 EST on February 18 had a frontal system extending southward over eastern Tennessee, Georgia, Alabama, and into the Gulf of Mexico. Subsequent developments, as depicted on the NMC Northern Hemisphere surface charts, are shown in figure 3. By 1300 EST, a closed Low had formed over Georgia. Further deepening occurred, and the storm moved rapidly toward the north-northeast to a position just north of Cape Cod at 0100 EST on the 20th.

Wind velocities for selected National Weather Service stations, as recorded in the NOAA Environmental Data Service publication, *Local Climatological Data*, are shown in table 1.

3. PRIMITIVE-EQUATION MODEL FORECASTS

Some of the PE model forecasts of storm positions and central pressures are shown in figures 4B–4D. The storm center positions and central pressures (fig. 4A), taken from the NMC Northern Hemisphere surface charts, can be compared to these 12-, 24-, and 36-hr forecasts. The shorter range PE forecasts of the track were consistent with the longer range forecasts and are considered to be quite good (except for the 12-hr forecast valid at 1900 EST on Feb. 18).

The PE model sea-level pressure forecasts (figs. 5B–5D), valid about the time of maximum storm surge, can be compared to the NMC pressure analysis in figure 5A. Here, it is seen that the longer range forecasts, such as the 30-hr forecast, underpredicted the magnitude of the storm intensity. The shorter range forecasts, such as the 6-hr forecast, look quite good, both for storm intensity and position.

4. CHARACTERISTICS OF THE EXTRATROPICAL STORM SURGE

Storm surge can be defined as the meteorological effect on the level of the sea. It is computed as the algebraic difference between the observed tide and the normal astronomical tide.

The principal factors involved in the generation and modification of the extratropical storm surge are:

1. The rise of water caused by the action of the wind stress on the water surface and consisting of two components. One component is the set-up of water by the onshore wind in which the slope of the water surface is directly proportional to the wind stress and inversely proportional to the water depth. The other component is the effect of the alongshore wind, which generates a current parallel to shore. The effect of the earth's rotation is to pile up water along the shore if the shore is to the right of the current.
2. The reduction of atmospheric pressure, generally called the inverted barometer effect, which causes an increase in sea level in areas of low pressure.
3. The transport of water by waves and swell in the shallow water area near shore.
4. The modifying effects of coastline configuration and the bathymetry, such as convergence or divergence in bays.

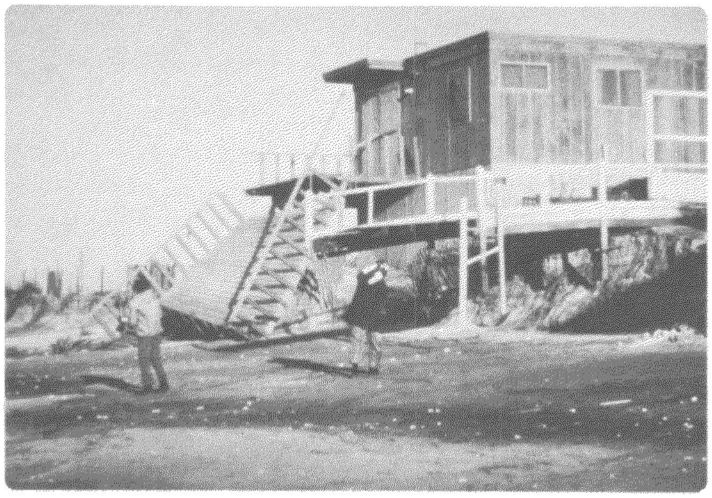

FIGURE 1.—Damage to porch and pilings at Westhampton Beach, N. Y., on the south shore of Long Island. (Photograph by the U.S. Army Corps of Engineers Coastal Engineering Research Center.)

FIGURE 2.—Results of undermining and caving in of concrete slab parking lot at Jones Beach, N. Y., on the south shore of Long Island. (Photograph by the U.S. Army Corps of Engineers Coastal Engineering Research Center.)

TABLE 1.—*Fastest observed 1-min wind speeds and directions for Feb. 19 and 20, 1972. Data are from the NOAA Environmental Data Service Publication,* Local Climatological Data

Station	Date	Direction	Speed (mi/hr)
Boston, Mass.	Feb. 19	NE	47
	Feb. 20	NW	47
Portland, Maine	Feb. 19	E	37
	Feb. 20	N	37
Providence, R.I.	Feb. 19	NE	32
	Feb. 20	NNW	32
Bridgeport, Conn.	Feb. 19	NE	46
	Feb. 20	WNW	48
New York, N.Y.	Feb. 19	NE	49
(La Guardia AP)	Feb. 20	NW	37
Atlantic City, N.J.	Feb. 19	NE	40
	Feb. 20	WNW	40
Baltimore, Md.	Feb. 19	NW	38
	Feb. 20	NW	36
Norfolk, Va.	Feb. 19	W	40
	Feb. 20	W	37

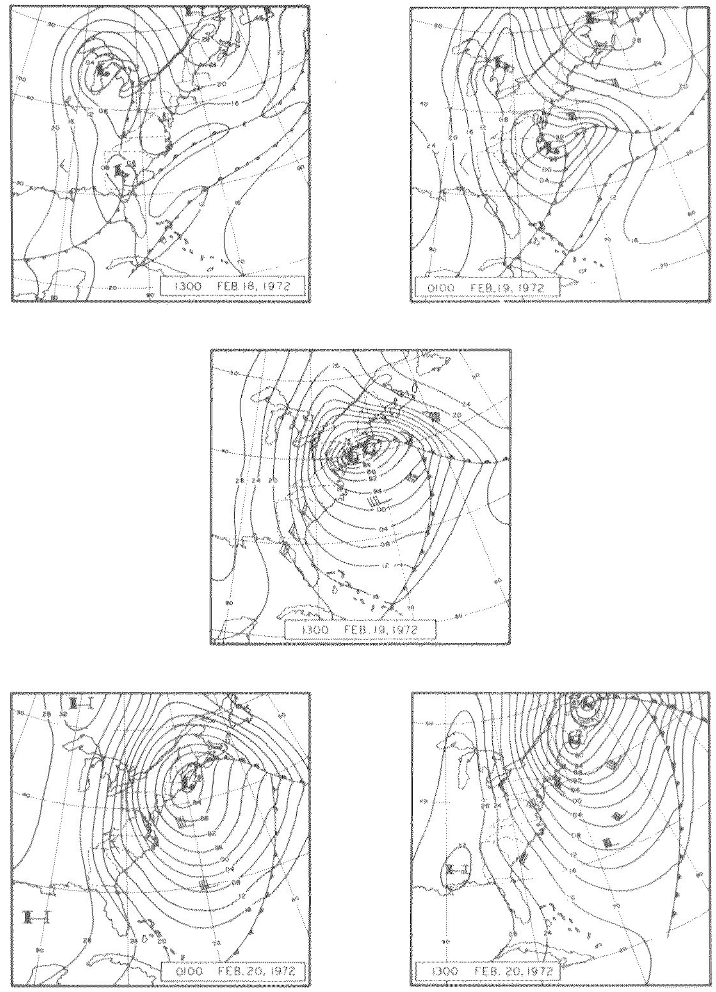

FIGURE 3.—Sea-level pressure analyses as shown on the NMC Northern Hemisphere surface charts. Times are EST.

5. THE OBSERVED TIDE AND STORM SURGE

Hourly values of the observed tide were obtained from the National Ocean Survey and were used to prepare figure 6 for the period February 17–21 for locations from Portland, Maine, to Hampton Roads, Va. Several features of the tide are obvious in this figure.

The semidiurnal nature of the tide, two highs and two lows daily, is evident. Also, the general increase in tide range toward the north is quite noticeable in this area. The station shown here with the smallest range of tide is Baltimore, with a mean range of 1.1 ft. Boston, with a 9.5-ft range, has the highest mean range among these stations.

On February 17, tides at these stations were running about normal. The effect of the storm is most noticeable in the tide curves for February 19th, when the tides were higher and more irregular. By the 20th, when strong offshore winds occurred, the tides became lower than normal. The storm greatly affected the tide at Baltimore after about noon on the 19th. Because the normal tide range is small at Baltimore, the storm effect dominated the water level. From about noon on the 19th and continuing through the 20th, Baltimore experienced strong west-northwest

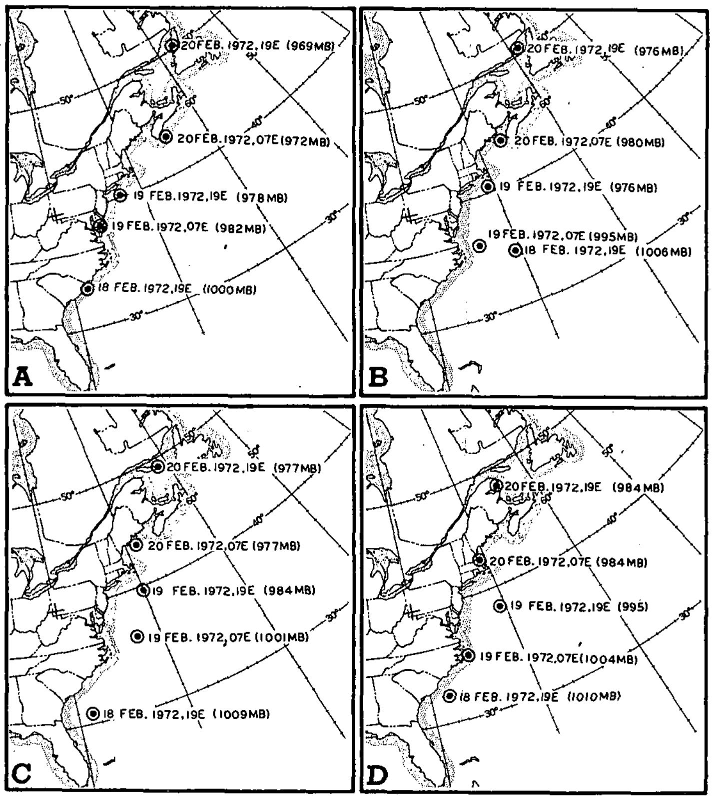

FIGURE 4.—(A) analyzed, and (B) 12-hr, (C) 24-hr, and (D) 36-hr forecast values of storm center position and central pressure. Data were obtained from NMC-analyzed sea-level pressure charts and gridpoint values of sea-level pressure forecasts of the PE model.

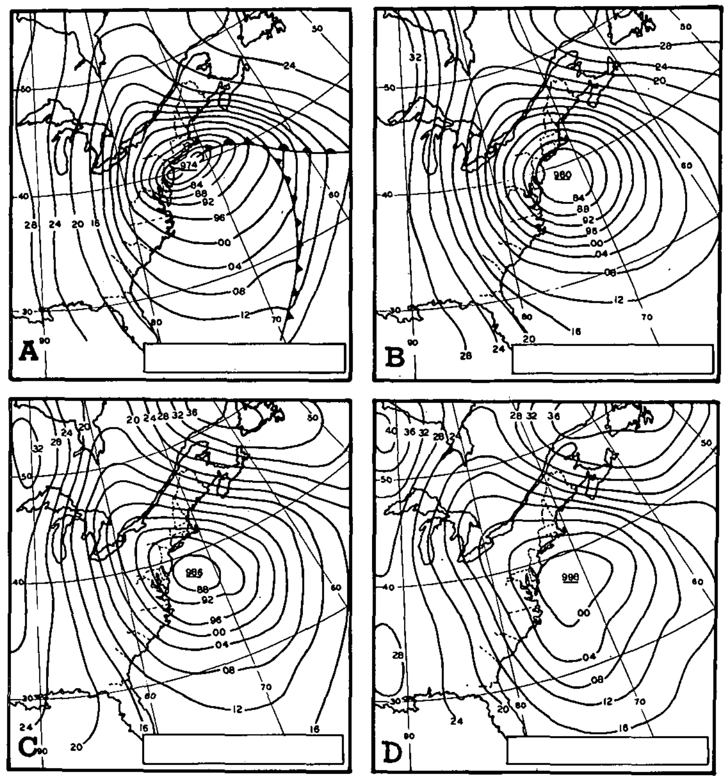

FIGURE 5.—(A) sea-level pressure analysis and (B) 6-hr, (C) 18-hr, and (D) 30-hr PE model forecasts valid at 1300 EST, Feb. 19, 1972.

winds that kept the Patapsco River, where the tide gage is located, quite low. The river is oriented northwest–southeast. This effect on tide level can be critical to navigation in ports with shallow channels such as Baltimore.

Curves of the storm surge (fig. 7) are more convenient for studying the effect of the storm on tide level. These curves are obtained by subtracting hourly values of normal tide from the observed tide. Maximum values of storm surge were large for several locations in Long Island Sound, where values reached 5.7 ft at Stamford, Conn., and Willets Point, N.Y.

The time of occurrence of storm surge with respect to the phase of the normal tide is of extreme importance. The times of normal high tide on February 19 for the locations in figure 7 are indicated in table 2. At nearly all of these stations, the maximum storm surge occurred near noon on the 19th, which happened to be near the time of normal high tide. If the maximum surges had occurred at normal low tide, the actual tide, of course, would have been much less. However, the situation could have been worse than it actually was if the surge had occurred either on the previous or the following high tide. Usually the two daily high tides are not of equal height and, in this storm, the surge occurred on the lower of the two high tides for that day. Actual tide heights would have been from 0.5 to 1.0 ft higher if the surge had coincided with the higher high tide.

TABLE 2.—*Times of normal high tide on Feb. 19, 1972*

Station	Time (EST)	Station	Time (EST)
Portland, Maine	1412	Port Jefferson, N.Y.	1436
Portsmouth, N.H.	1430	Willets Point, N.Y.	1418
Boston, Mass.	1430	Battery, N.Y.	1136
Sandwich, Mass.	1424	Sandy Hook, N.J.	1100
Buzzards Bay, Mass.	1200	Atlantic City, N.J.	1018
Providence, R.I.	1118	Breakwater Harbor, Del.	1136
Newport, R.I.	1054	Baltimore, Md.	1012
Stamford, Conn.	1427	Hampton Roads, Va.	1218
Montauk, N.Y.	1206		

6. AUTOMATED STORM SURGE FORECASTS

The automated storm surge forecasts are based on the sea-level pressure forecasts at specific NMC gridpoints (Pore 1970). A separate multiple regression equation was derived for each location. Sixty-eight storm surge cases from 1956 through 1969 were used in these derivations.

A storm surge forecast is made twice daily, following each PE run. For each of nine forecast locations from Portland to Hampton Roads, storm surge forecasts are made out to 36 hr at 6-hr intervals. An example of the Teletype message (FZUS3) as sent on Circuit 7072, and the forecast locations, are presented in figure 8. This is the forecast message for 0000 GMT of February 19. The heading line above each column gives the forecast valid times.

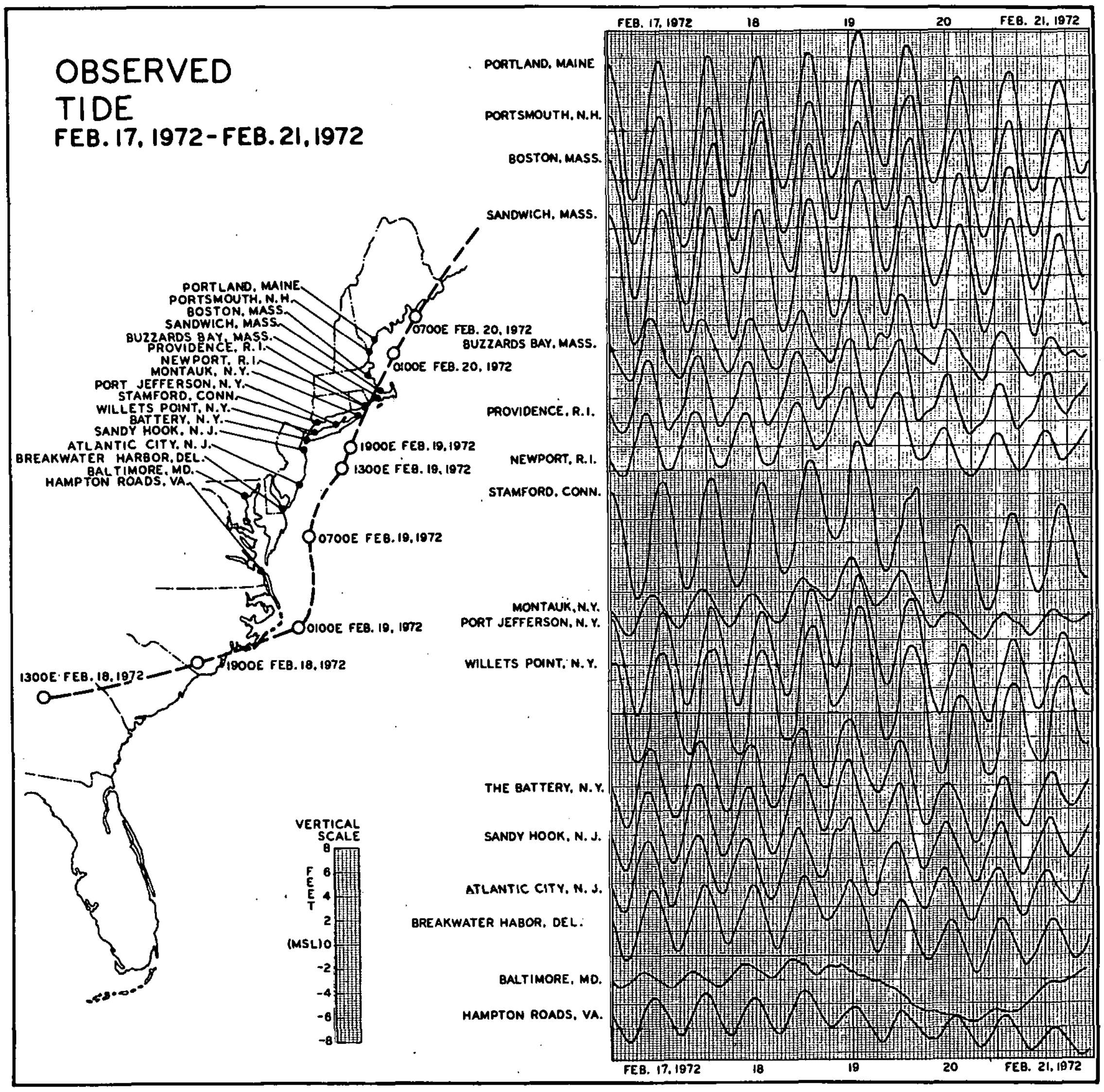

FIGURE 6.—Six-hourly positions of the storm center and observed tide as recorded by tide gages of the National Ocean Survey. (The date for each day of record is placed at the 1200 EST position.)

Calculations of the storm surge based on sea-level pressure analyses and forecasts are shown in figures 9–12. Storm surge calculations based on sea-level pressure analyses of the NMC Northern Hemisphere surface charts are shown by the dots at 6-hourly intervals on figure 9. Here, the observed storm surges, based on hourly values, are shown by the solid curves. Maximum values of observed surge are printed near the peak of each curve. These storm surge calculations agree fairly well with the observations. Figures 10–12 show, in the same manner, actual forecasts of surge, based on the PE sea-level pressure forecasts. Figure 10 shows 6- and 12-hr forecasts of the surge. Two forecast intervals are combined on one chart so that there are forecast values every 6 hr rather than every 12 hr.

The actual forecasts of storm surge, of course, are not as accurate as the calculations based on the pressure analyses. The underforecasting of storm intensity by the PE model in the longer range forecasts was discussed earlier and is reflected in the longer range forecasts of storm surge as shown in figure 12. The 6- and 12-hr surge forecasts were closer to the observed surge than the longer range 30- and 36-hr forecasts. On the whole, the automated storm surge forecasts provided useful guidance material, especially on the timing of the surge.

7. OBSERVED OCEAN WAVES

Waves caused by the storm and superimposed on the storm surge caused much damage to structures and to beaches as indicated in the photographs shown in figures 1 and 2. Strong onshore wind affected the Middle Atlantic and New England coasts when the storm was along the mid-Atlantic coast. As the storm moved northward, the winds affecting the coast became strong offshore winds. The wind and wave reports, as plotted on the NMC Northern Hemisphere surface charts for the period 1300 EST on February 18 to 0700 EST on February 20, are shown in figures 13 and 14.

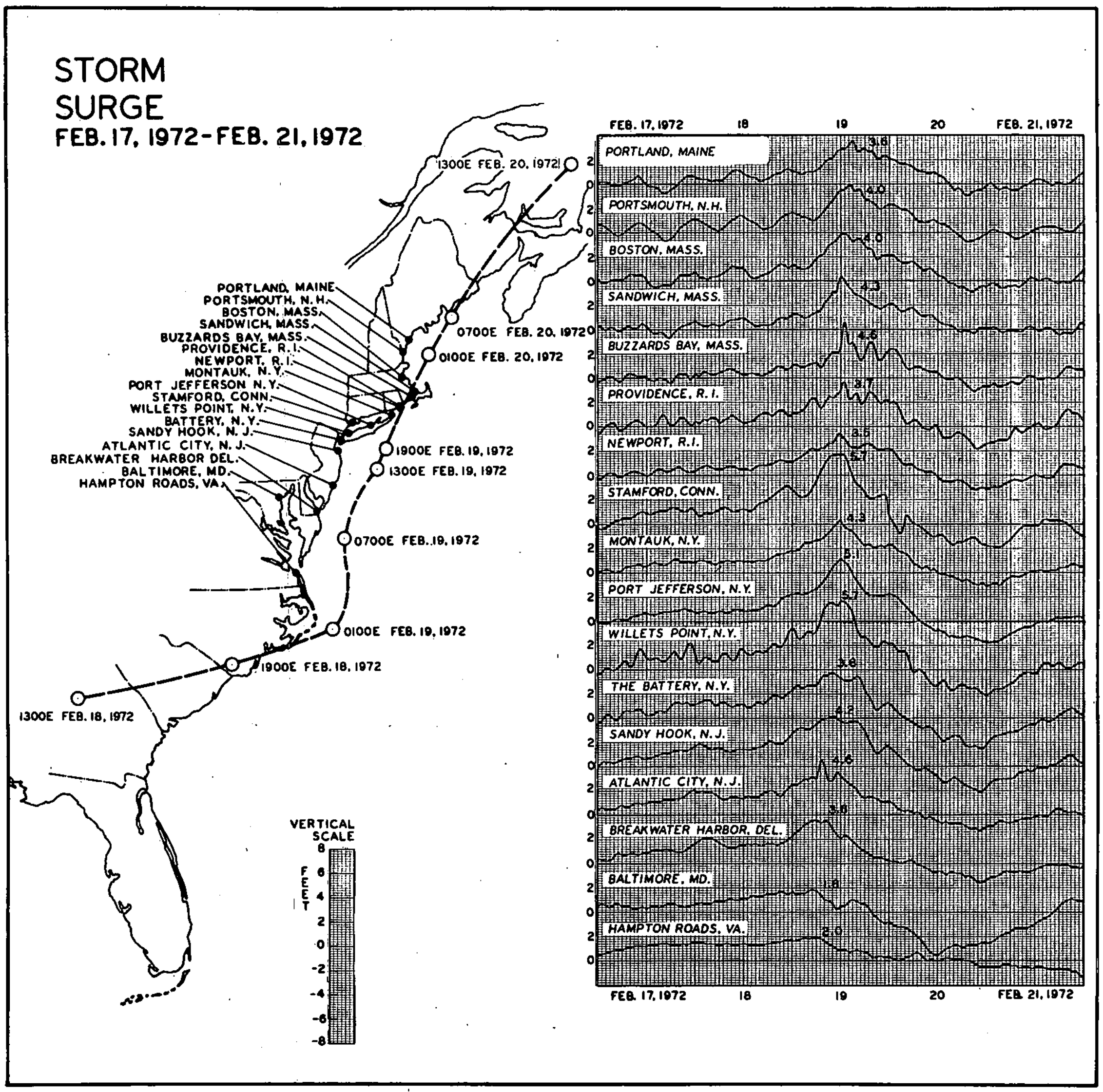

FIGURE 7.—Six-hourly positions of the storm center and the storm surge (observed tide minus the normal astronomical tide.) The maximum value (ft) is indicated on each curve and the date for each day of record is placed at the 1200 EST position.

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FZUS3 KWBC 190000
EAST COAST STORM SURGE FORECAST IN FEET
           00Z  06Z  12Z  18Z  00Z  06Z  12Z
    PWM    0.5  0.9  1.1  1.7  2.2  2.0  1.7
    BOS    0.7  1.2  1.3  2.1  2.5  2.1  1.6
    NWP    1.2  1.7  1.5  2.0  2.1  2.0  1.9
    SFD    2.8  3.3  3.4  4.4  4.2  3.6  2.7
    JFK    2.1  2.2  2.4  2.3  2.5  1.8  1.0
    ACY    1.7  2.2  2.0  2.4  2.1  2.0  1.4
    BWH    1.8  2.3  2.0  2.3  2.0  1.5  0.9
    BAL    1.9  1.8  2.3  1.2  1.3  0.7  0.2
    ORF    2.0  2.7  1.9  1.9  1.3  1.0  0.3
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FIGURE 8.—Storm surge forecast Teletype message for 0000 GMT, Feb. 19, 1972. Valid terms are indicated above each column of heights (ft). Stations are Portland, Maine (PWM), Boston, Mass. (BOS), Newport, R. I. (NWP), Stamford, Conn. (SFD), Battery, N. Y. (JFK), Atlantic City, N. J. (ACY), Breakwater Harbor, Del. (BWH), Baltimore, Md. (BAL), and Hampton Roads, Va. (ORF).

The wave reports shown in these figures are plotted in the conventional manner with the first group referring to the wind waves and the second group, if reported, referring to swell. The last two digits of each group indicate the wave height in half-meters. For example, the highest wind-wave report shown in figure 14 is on the 1900 EST chart for February 19. The ship at 37.4°N, 71°W reports 13 half-meters or 21 ft. This is the estimate of significant wave height, which is the average height of the one-third highest waves. The highest waves are about 1.9 times the significant wave height.

8. AUTOMATED OCEAN WAVE FORECASTS

The wave forecast program for wind-wave and swell conditions uses the 1000-mb level adjusted wind forecasts of the PE model as input (Pore 1970). Forecasts of significant wave height are based upon a weighted wind speed and the duration time of wind from a relatively constant direction. The higher of the forecast wind-waves are propagated in their respective directions and at their particular speeds, dependent on wave period, to form swell forecasts.

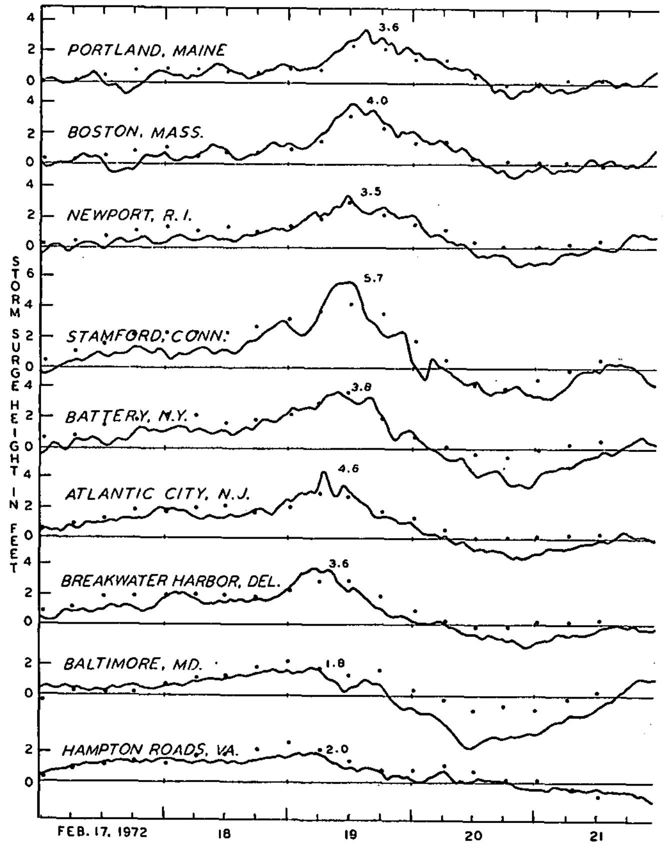

FIGURE 9.—Observed (solid curves) and calculated (dots) storm surge. Calculated values are based on sea-level pressure analyses. Maximum value (ft) of observed surge is placed near the peak of each curve and the date is placed at the 1200 EST position.

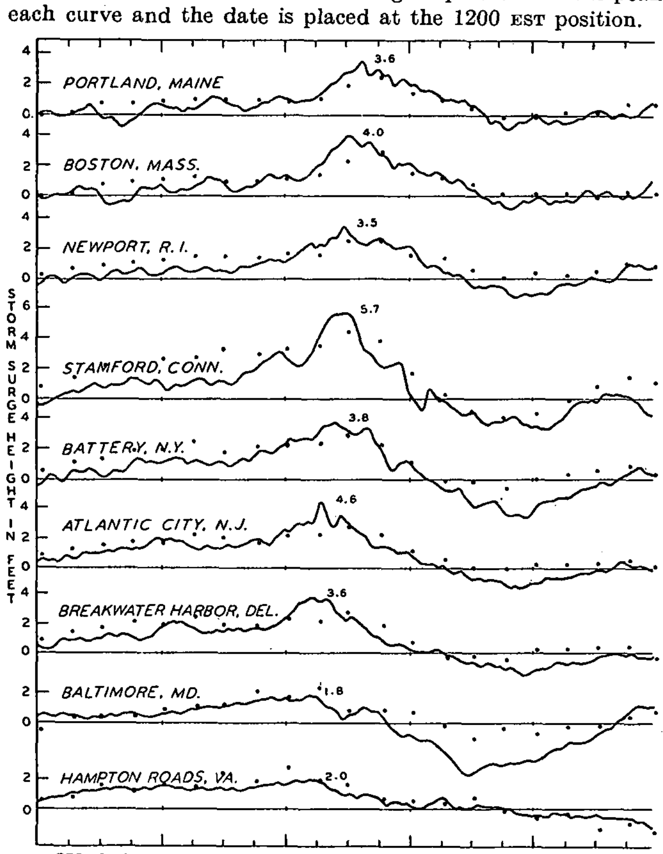

FIGURE 10.—Same as figure 9 except dots indicate forecast storm surge. Forecast values are based on 6- and 12-hr sea-level pressure forecasts from the PE model.

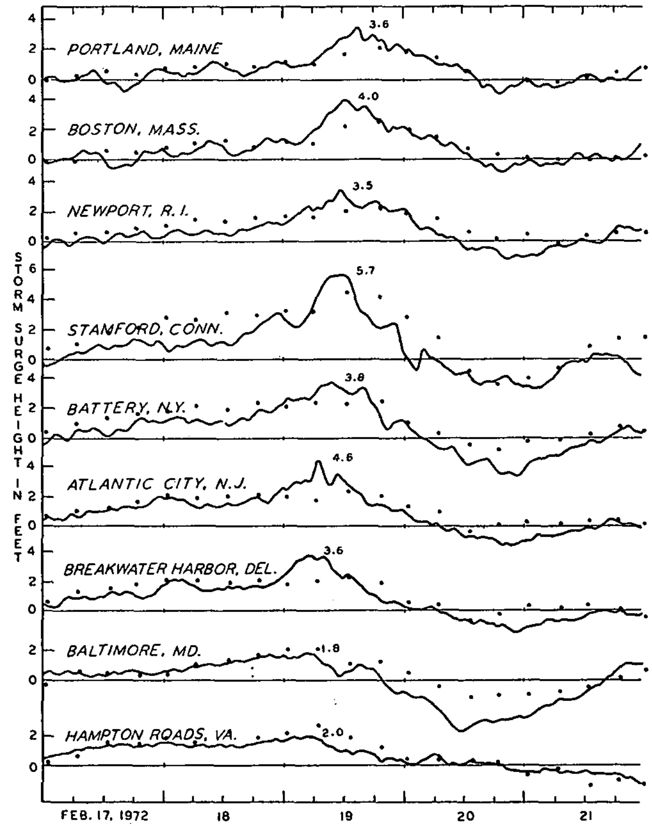

FIGURE 11.—Same as figure 10 except forecast values are based on 18- and 24-hr sea-level forecasts of the PE model.

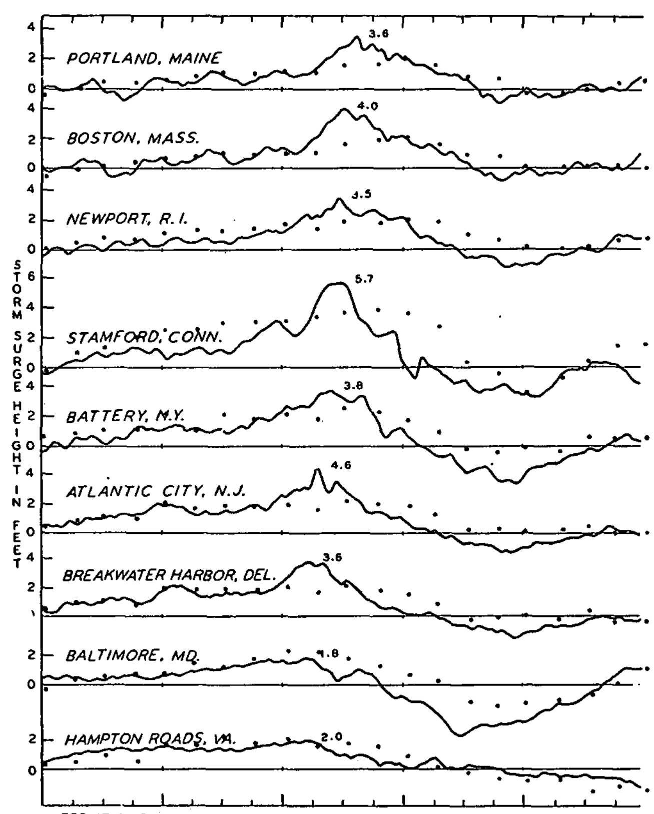

FIGURE 12.—Same as figure 10 except forecast values are based on 30- and 36-hr sea-level forecasts from the PE model.

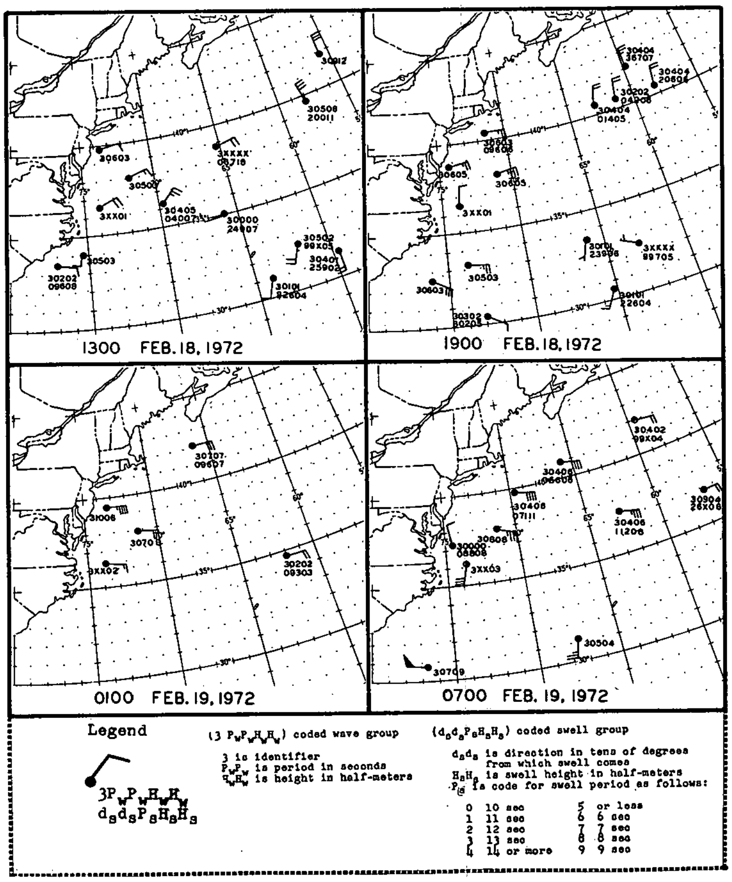

FIGURE 13.—Wind and wave reports as shown on the NMC Northern Hemisphere surface analysis charts for the period 1300 EST, Feb. 18–0700 EST, Feb. 19, 1972.

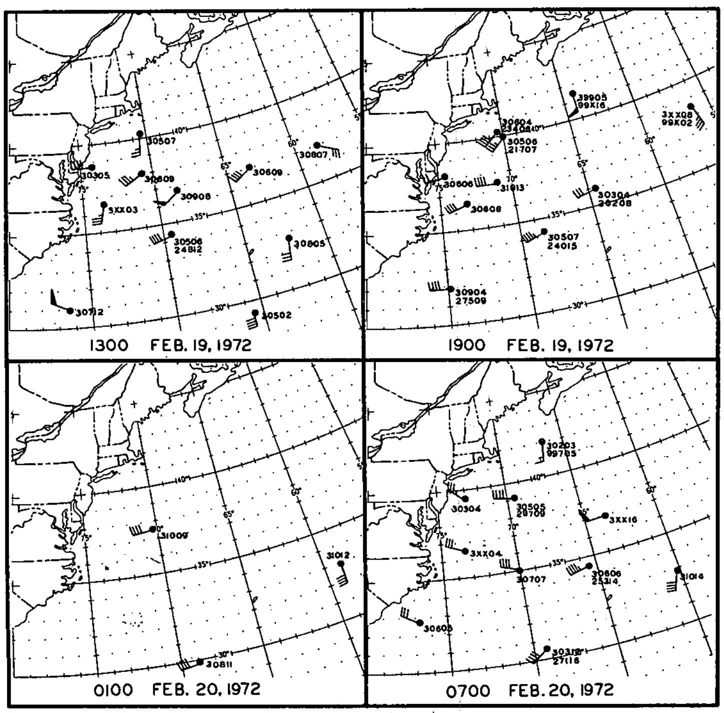

FIGURE 14.—Same as figure 13 for the period 1300 EST, Feb. 19–0700 EST, Feb. 20, 1972.

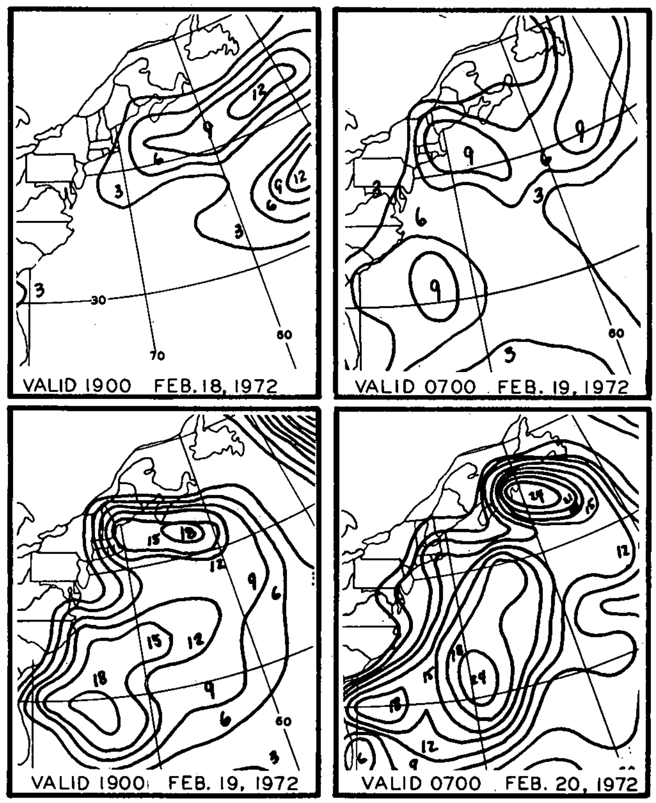

FIGURE 15.—Twenty-four-hour wind-wave forecasts based on the PE model adjusted 1000-mb wind forecast. Contours indicate significant height in feet and time is EST.

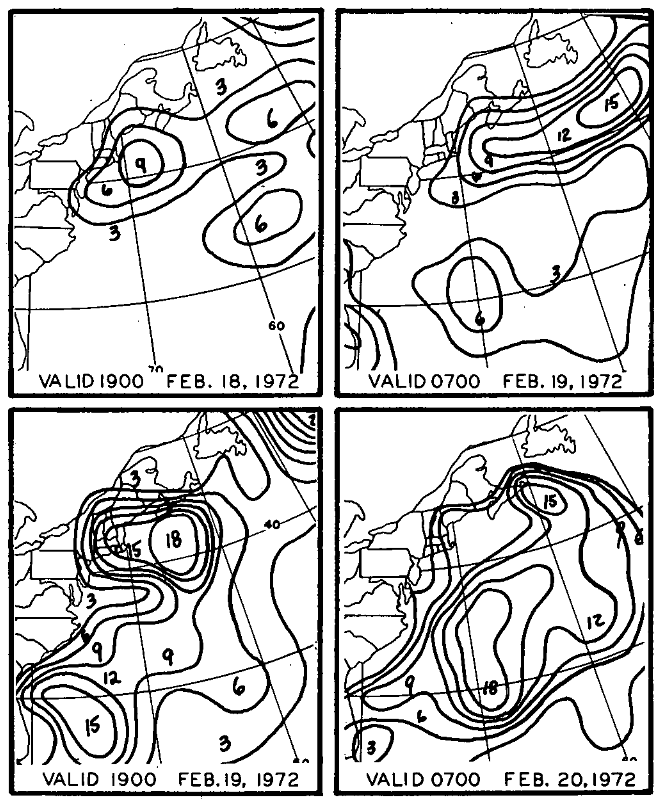

FIGURE 16.—Same as figure 15 for 36-hr forecasts.

The 24- and 36-hr wind-wave forecast charts and the 36-hr swell charts valid from 1900 EST on February 18 to 0700 EST on February 20 are shown in figures 15–17. These charts are portions of those that were transmitted on the FOFAX Teletype circuit. These wave forecasts cannot be

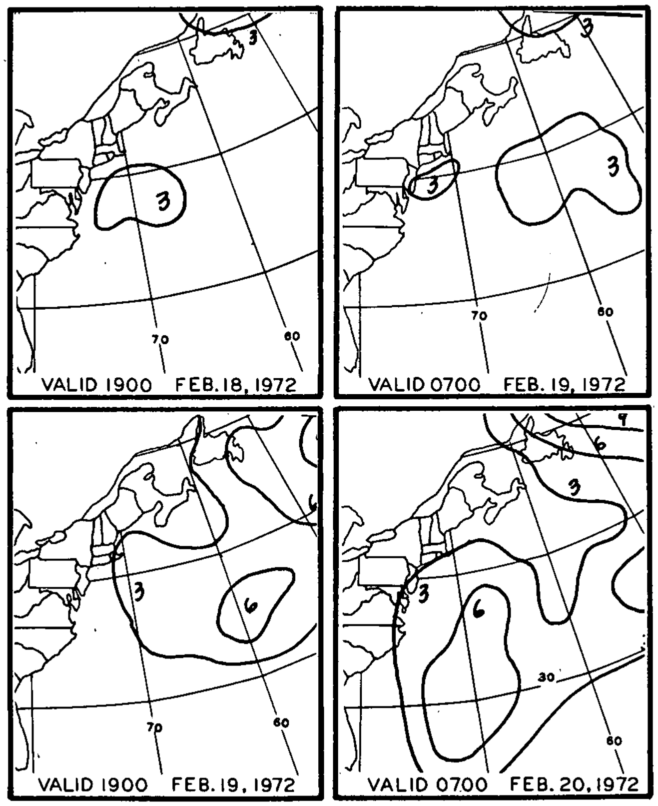

FIGURE 17.—Thirty-six-hour swell forecasts based on the PE model adjusted 1000-mb wind forecast. Contours indicate swell height in feet and time is EST.

accurately verified, as observations are available only where ships happen to be. Also, visual wave observations are extremely difficult to make. However, by considering the available reports and the surface pressure analyses and forecasts, it is felt that these wave forecast charts are reasonable.

9. SUMMARY

The storm of Feb. 18–20, 1972, caused extensive damage along Long Island and New England beaches. The meteorological forecasts of the National Meteorological Center were good, especially for the track of the storm. The resulting automated storm surge and ocean wave forecasts were also reasonably accurate.

ACKNOWLEDGMENTS

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